Model-based Hyperspectral Exploitation Algorithm Development

Dr. John Schott
Rochester Institute of Technology
54 Lomb Memorial Drive
Rochester, NY 14623
phone: (585) 475-5170 fax: (585) 475-5988 email: schott@cis.rit.edu

Dr. Glenn Healey
University of California, Irvine
The Henri Samueli School of Engineering
Irvine, California 92697-2625
phone: (949) 824-7104 fax: (949) 824-2321 email: healey@ece.uci.edu

Dr. William Philpot
Cornell University
453 Hollister Hall
Ithaca, NY 14853
phone: (607) 255-0801 fax: (607) 255-9004 email: wdp2@cornell.edu

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LONG-TERM GOALS

Hyperspectral data is becoming a critical tool for military planners. The capture of fine spectral information enables the generation of information products, which could not be produced using traditional imaging means. The challenge facing the insertion of hyperspectral technology, as an operational capability, is with conversion of the raw sensor data into a useful information product that is accurate and reliable. The long-term goal of this project is to develop a new generation of hyperspectral processing techniques that result in the production of valuable information products.

OBJECTIVES

The objectives of this project are to develop hyperspectral-processing techniques that incorporate physics-based processing techniques in the following application areas:

- Water quality and biological activity (littoral zone)
- Material classification and identification
- Atmospheric parameter retrieval/correction
- Gaseous effluent detection and quantification

The output of this project will be processed data sets and, in some cases, information products that demonstrate what is feasible.

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14. ABSTRACT
Hyperspectral data is becoming a critical tool for military planners. The capture of fine spectral information enables the generation of information products, which could not be produced using traditional imaging means. The challenge facing the insertion of hyperspectral technology, as an operational capability, is with conversion of the raw sensor data into a useful information product that is accurate and reliable. The long-term goal of this project is to develop a new generation of hyperspectral processing techniques that result in the production of valuable information products.

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APPROACH

Traditional approaches for processing hyperspectral data have largely focused on the use of statistical tools to process a hypercube, with little regard for other data that may describe the physical phenomena under which the data was collected. The RIT MURI research team has been developing physics-based models that enable the environment, under which remotely sensed data is collected, to be better described (Schott 2000). Under this MURI project, we are using these physics-based models, along with statistical processing techniques to evaluate the effectiveness of this approach for processing hyperspectral data sets.

Key individuals that make up the RIT MURI research team include:

- Dr. John Schott [RIT] - Principal Investigator overseeing the project research activities.
- Dr. Glenn Healey [UC, Irvine] – Developing invariant algorithm approaches and specific applications for material identification.
- Dr. William Philpot [Cornell University] – Developing techniques for modeling the inherent optical properties of water and supporting the littoral zone modeling.

WORK COMPLETED

The RIT MURI team has just completed its first year of research activity. The first year has focused on definition of the underlying phenomenology and development of physics-based models for each application area. In several application areas, hyperspectral data sets have been processed.

RESULTS

The following is a summary of key results by application area:

- Water quality and biological activity (littoral zone). This year's effort focused on refinement of a method to use on in-water radiative transfer code, Hydrolite (c.f. Mobley 1995) and on atmospheric propagation code (Modtran) (c.f. Berk et al. 1989) to generate remotely sensed spectral reflectance as a function of the primary coloring agents. These concentrations are then recovered on a per pixel basis using a model matching and inversion routine (c.f. Raqueno et al. 2001).
  - open water model-based-model-match algorithm implemented and tested to determine in-water constituents from LEO-15 data set.

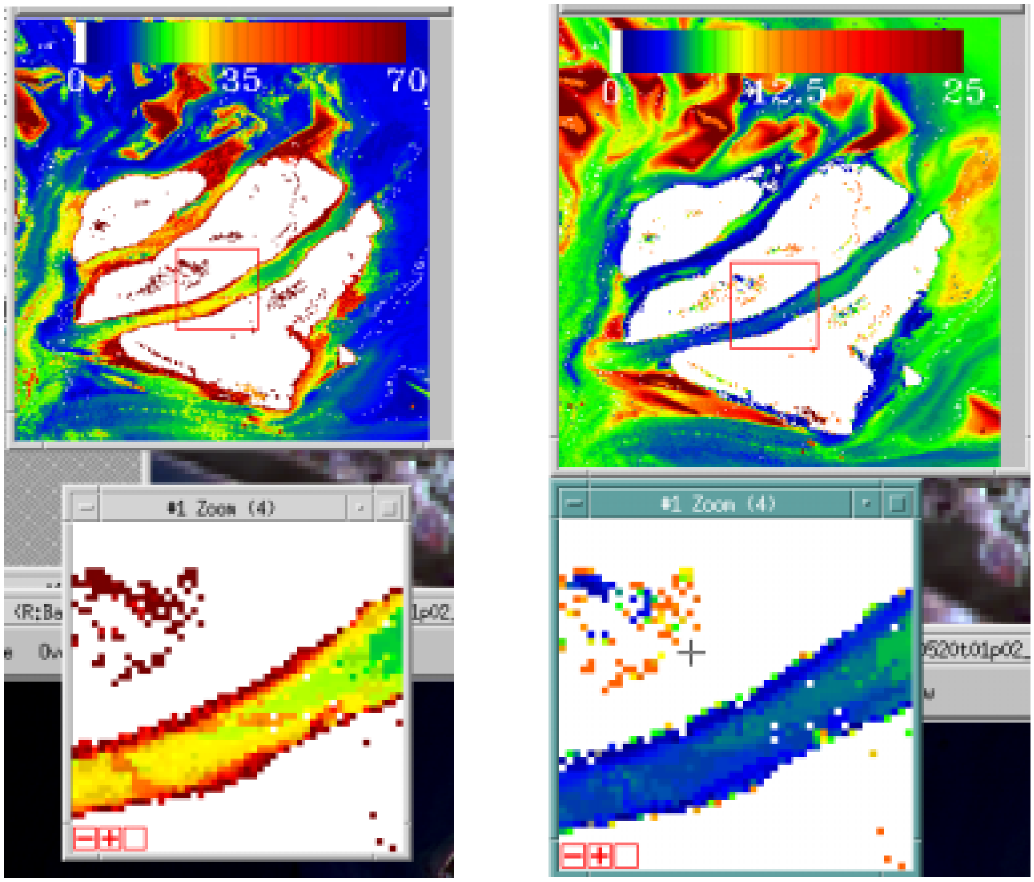

Figure 1: Processed LEO-15 Data Set, CHL vs. TSS estimates.

- Atmospheric parameter retrieval and correction

\- initial TIR atmospheric characterization algorithm implemented to yield per pixel atmospheric profiles, temperature and water vapor, and surface temperature.

- Gaseous effluent detection and quantification

\- stack plume model implemented with enhanced in-plume radiative transfer

\- initial gas detection algorithm approach identified

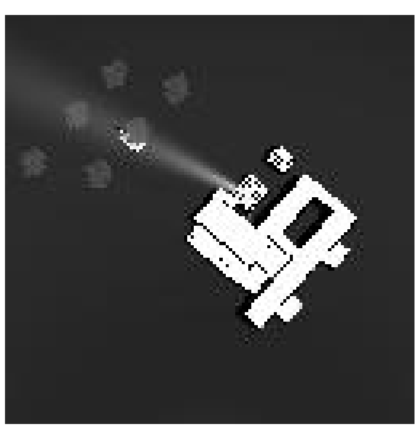

Figure 2: Physics-based DIRSIG simulation of a gaussian plume model and a simplified background.

- Material classification and identification
  - algorithm developed to take advantage of 3D spatial/spectral models
  - subpixel invariant algorithm developed and initial results promising (c.f. Lee 2002).

Figure 3: UCI Invariant Algorithm applied to a HYDICE scene with hidden panels accurately identified.

IMPACT/APPLICATIONS

The RIT MURI Team believes that this research work can have a significant impact in how hyperspectral data is process and how the resulting information products are generated. The invariant algorithm research is already showing promise in reducing false alarms under varying collection conditions. The water modeling activity is showing promise for a more accurate representation of shallow water optical conditions, thus allowing more accurate detection of objects in the water.

TRANSITIONS

RIT recently initiated a research project with the National Imagery and Mapping Agency that involves the implementation of algorithms into an ENVI software environment. One of the algorithms developed under this program has already been identified as a candidate algorithm for implementation under this NIMA effort.

RELATED PROJECTS

- NIMA University Research Initiative (NURI) – RIT project that involves the implementation of advanced hyperspectral algorithms into an ENVI software environment and then conducting robustness testing to evaluate performance. This project started June 2002.

- Army Research Organization (ARO) Multidisciplinary University Research Initiative (MURI) – RIT is on a research team led by Georgia Institute of Technology to develop multi and hyperspectral processing techniques for tactical sensors (UAV and helicopter platforms). RIT's role will be in the generation of physics-based models using DIRSIG. This project will start October 2002.

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